Ohio Agricultural Experiment Station

CIRCULAR No. 125

WOOSTER, OHIO, MAY 20, 1912

APPLE BLISTER CANKER AND METHODS OF TREATMENT

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It is increasingly evident that serious apple diseases must lie back of the reported dying of mature apple trees in many parts of Ohio. Field studies of conditions, supplemented by laboratory examination made during the season of 1911 and the early spring of 1912, show that serious cankers are present in these diseased orchards. By the term canker we refer to any apparent bark disease of fruit trees. In these diseased areas the symptoms of dying bark and extension of disease causing an enlargement of the spots, are usually evident.

Attention to a form of canker was first called by Paddock in 1899[2]. This was with respect to the canker caused by the black-rot fungus, *Sphaeropsis malorum* Pk., and known as the New York apple tree canker. Subsequent investigations in Illinois by Hasselbring[3] brought out that the most serious canker disease of that state is that caused by the fungus *Nummularia discreta* Tul., and named by him the Illinois apple tree canker. For purposes of this discussion it is somewhat better to adopt the characteristic descriptive common name of "blister canker" for the disease caused by this fungus.

Our studies in Ohio, although up to this time largely of a preliminary nature, show that the blister canker, more particularly in the southern half of the state, is a very serious disease, for by means of its attacks on apple trees it is capable of inflicting increasing damage and loss to the orchardist.

It is believed that blister canker is not a new disease in Ohio, for judging from present conditions, the disease has been with us for many years. It is impossible to imagine that this disease could possibly spread so generally throughout the whole state in less than a generation. It was found in the northern portion of the state where

[1] Mr. Gloyer is not at present connected with the Station. Letters pertaining to the work on Blister Canker should be addressed to Experiment Station, Wooster, O.

[2] Paddock, W. The New York Apple Tree Canker. Bulletins N. Y. Agricultural Experiment Station 163:(1899) and 185:(1900).

[3] Hasselbring, H. "Canker of Apple Trees," Bulletin Illinois Experiment Station 70:1902.

it attacks an occasional tree, and as one travels southward he finds more and more of the blister canker, until in the region south of Columbus the disease is so plentiful that it may be considered dangerous. In orchards situated in southern Ohio, from 1 to 90 percent of the trees may be attacked; and there seems no reasonable doubt that this fungus is causing a loss of thousands of dollars annually. Clearly, under such circumstances it should receive the utmost attention.

THE BLISTER CANKER FUNGUS, *Nummularia discreta* Tul.

The blister canker fungus was first described in America by Schweinitz[4] in 1834, when it was described as *Sphaeria discreta* Schw. He noted at that time that its occurrence was common in the East upon the limbs of the apple tree. In 1863 the Tulasne Bros.[5], two French monks, gave an excellent portrayal and description of this parasite. They report the fungus as occurring on Sorbus and Magnolia. Later it was reported on other trees. In 1892 Hasselbring[6] described this disease as occurring in Illinois, but his description has added but little to that already known of the habits and characteristics of the parasite.

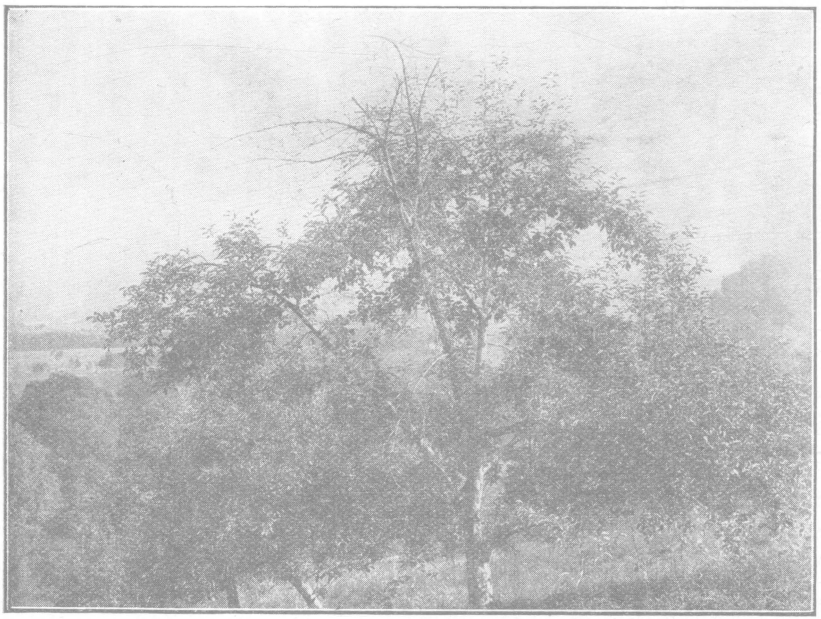

Fig. 1. Apple tree with a high branch killed by Blister Canker. In Gallia county orchard, October, 1911.

[4] Trans. of the Am. Philos. Soc., 4:1834; 195, No. 1249.
[5] Tulasne, Sel. Fung. Carp. 2:45; 1863.
[6] Hasselbring, Bul. Ill. Expt. Sta. 70:1902.

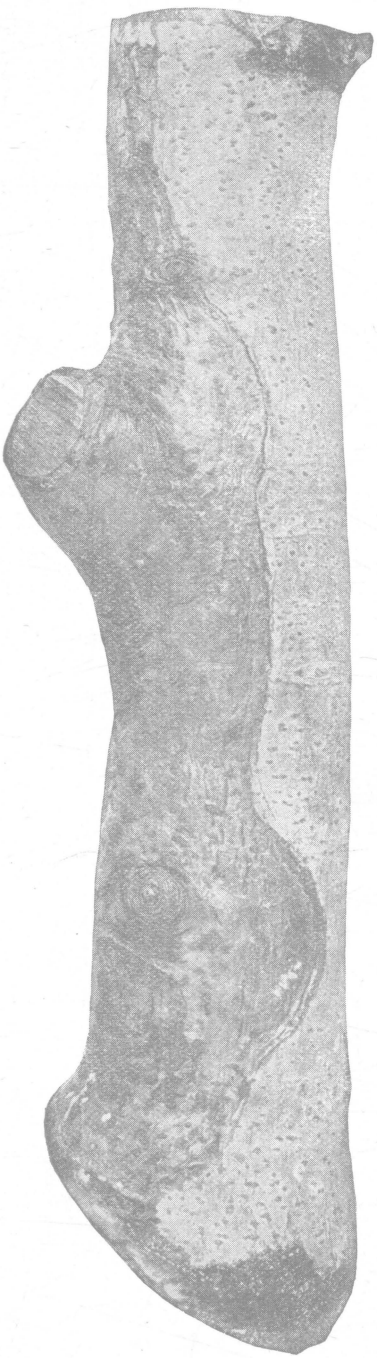

Fig. 2

Fig. 3

Fig. 3. Larger branch of apple showing scar from which branch, shown in Fig. 2, has been removed. Note here the darkening heartwood due to effects of the canker fungus and oxidation. This also shows proper type of close pruning to remove branch.

Fig. 2. Branch of apple with *one year old* Blister Canker which apparently entered from pruning stub shown. Note line of separation of healthy and cankered bark. This branch sawed from wound in Fig. 3. From Gallia county, October, 1911.

The canker is readily observed on trees by individuals who have learned to recognize its appearance and its effect on the host. One can see from afar the dead branches in the tops of trees that were killed by this fungus. In examining the branch, if it should be over two inches in diameter at its base, one may usually find the blister canker cutting off the sap flow and causing the apples to shrivel and become pulpy. Both the leaves and apples may cling to the twigs for some time, but the apples hang on more tenaciously. Fig. 1 shows this condition clearly. It was brought out conspicuously during the drouth of July and August, 1911.

At the base of such a branch one may see light tan-colored discs, or one may observe protrusions which resemble nail heads. These blister-like appearances have characterized this disease and hence it has been given the appropriate name of "blister canker." From these discs or protrusions, called stroma, there arise two kinds of spores which spread the disease from tree to tree.

PRODUCTION OF FIRST SEASON CANKERS

Should one of these spores fall upon a proper lodging place—for this is a wound parasite—it may germinate under proper conditions of moisture and temperature by sending out a small tube or hypha, which usually enters the woody tissue that has become dry to a certain extent by exposure to the air. This region would naturally be the center of the wound left by the removal of a branch or limb. The fungus grows into the tissue as long as there is sufficient oxygen and moisture present. The fungus mycelium or mass of hyphae may penetrate the heart wood for some distance before it crowds outward to the region containing the conductive tissue, when the disease makes itself evident to the naked eye as a dark brown area of diseased bark. If the wound consists of a rupture in the bark the fungus readily penetrates the bark and finally enters the conductive tissues until it reaches the heart wood, where it may grow more or less rapidly. In the bark, the fungus does not advance regularly, but may penetrate a certain portion of the tissue and leave a small area unattacked. The growth in the bark tissues first appears to be very rapid, then it suddenly ceases. The healthy tissue continues to grow and makes a faint attempt to cut off the further advance of the fungus. This is done by a slight growth of the bark cambium toward the dead tissues, but this is not successful, for the next season the growth continues and the spot increases in size. The growing tissue and the drying, dead, brown colored bark may form a fissure or crack so that one can observe the age of the canker.

FORMATION OF THE BLISTER-LIKE STROMA AND SPORES

In the months of July and August the fungus develops stroma or masses of mycelium in certain portions of the diseased bark, and from these stroma the spores arise. The formation of stroma however does not always occur, for often one can observe branches that have been killed by this fungus and still no evidence of the characteristic discs or spores can be found. The stroma are exposed by the cracking of the epidermis above them, exposing the light tan-colored discs.

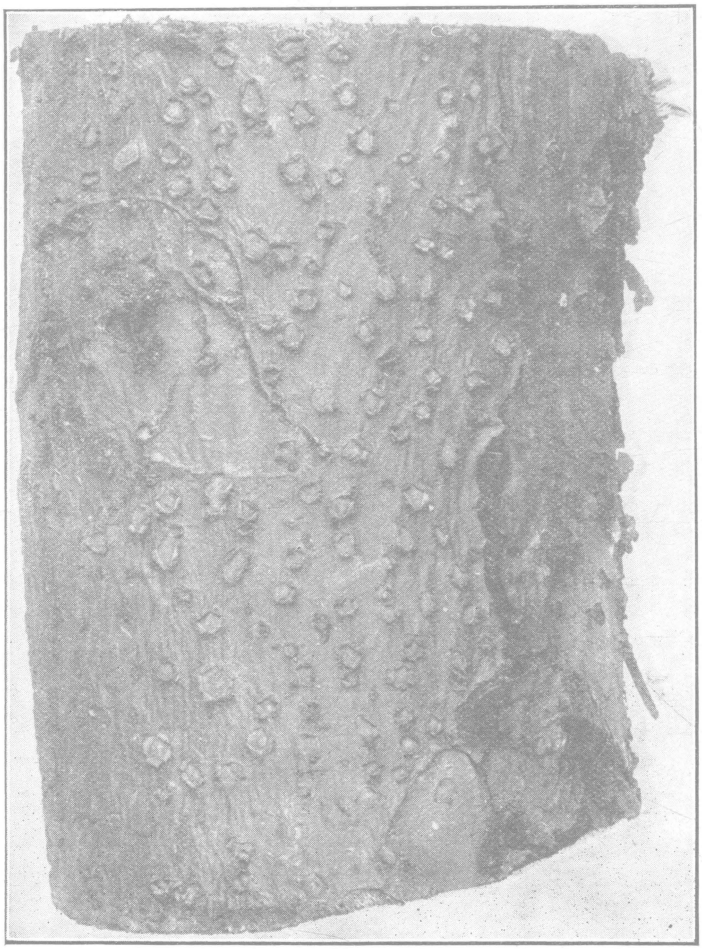

Fig. 4. Apple branch showing one year old case of Blister Canker. Note the epidermis covering the stroma has cracked and curled back to expose the surface from which the spores or conidia arise. Should the surface of the bark be cut before the epidermis has curled back then the outlines of the stroma can be clearly seen.

The spores (conidia are honey-colored, oval, one celled, 3x6 microns (1 micron equals 1-25,000 of an inch), and are borne on more or less branched mycelium (conidiophores) which arises from the surface of the stromatic mass. The spores are readily set free and are distributed by the wind to neighboring trees and infect wounds; or the rain may wash the spores down the tree to another rupture in the bark and a canker may result. Hasselbring states that he has been unable to germinate these conidia. I have found, from specimens collected in August, that the condia are quite viable for they germinate in distilled and well water, prune decoction, and a 4 percent sugar solution even after having been kept in the laboratory for three months. About 30 percent of the spores germinated in this case. The conidia also germinated on dead bark after having keen kept for three days in a damp chamber. This would tend to show that damp weather is favorable for the germination of the conidia, and that infection may result from this source.

Another form of spore or perfect stage of this fungus is also produced. In it the spores are contained in protecting spore sacs called asci. The stromatic mass of tissue, which is about 1-4 to 3-8 by 3-16 to 1-4 of an inch in size, is attached to the wood by fungus tissue and may be still adhering to the tree after 7 to 10 years without having become loose. The stroma are at first soft and spongy, but upon aging they become brittle and bone-like. Externally, when old, they are of black color and internally they are a yellow-green to tan color. Their circumference is irregular, due to the disintegration of the dead, nonstromatic tissue around them. Often, in going about the State, I have observed a dead apple log, which still had these stroma upon it rolled into some out-of-the-way place to rot.

In the months from April to June there are transformations taking place inside the stromatic mass which the year before produced the conidia on its surface. These transformations lead to the formation of bottle-shaped spore cases or perithecia which contain the sac-shaped spore cases or asci. The perithecia are arranged in a layer and are about 4 to 6mm. long. The cylinder shaped spore sacs (asci) which gradually taper at the base, are about 160x13 microns, and distributed among them are long, mycelial, sterile threads or paraphyses. The black, almost spherical spores are 11x13 microns in size and each ascus contains 8 spores. About half way around these spores there is a lighter band of tissue, through which the germinating hypha emerges. However, in very old spores this band is not readily observed. Under favorable conditions one can see the spores exuded from the perithecium and cast upon the surface of the stroma. Nature, however, has afforded them an excellent protection that often

hinders the spores from escaping. This hindrance lies in the form of a small cap that is about 1-8 of an inch thick which covers the openings of the perithecium. This cap must be removed before the spores can escape, and this is done through sloughing it off by disintegration. Sometimes it may require two to three years before this is accomplished, but usually the cap disappears within a year. The ascospores are then able to be sent forth and may under favorable conditions of moisture and temperature germinate, and if alighting upon the proper place, such as a wound, infection may result.

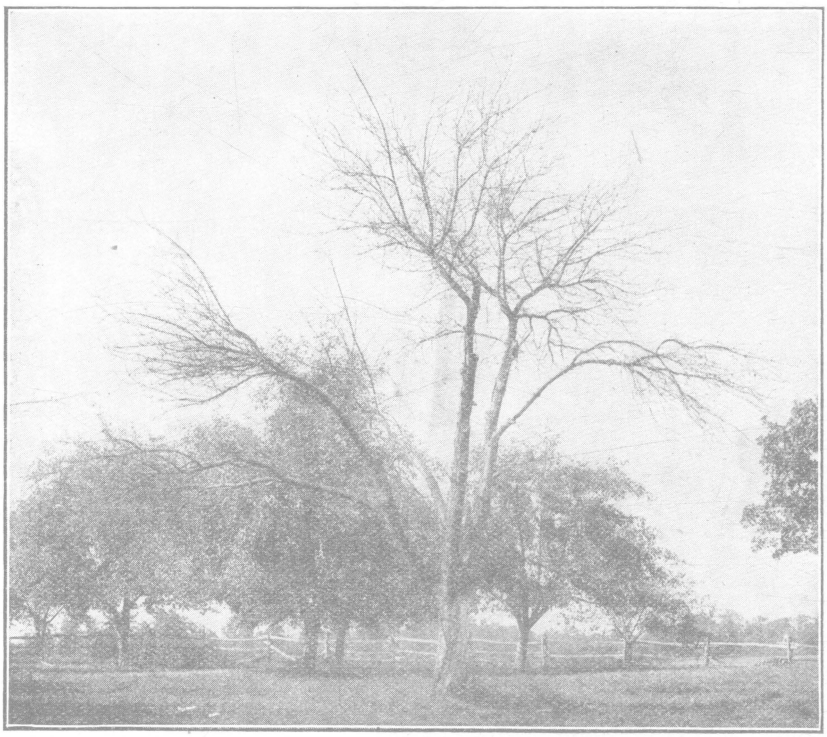

Fig. 5. Apple tree killed by Blister Canker. Note the loss of bark on central branches above, also extending to ground on right side of trunk. Remainder of bark was also loose. Gallia county, October, 1911.

EFFECT ON APPLE TREE

When a branch is attacked by the blister canker fungus the disease finally girdles it and the portion of the limb above the canker withers and is killed. The branches above the canker become ragged due to the cracking and peeling of the epidermis and the bark. This in time falls off or is torn away by the wind and rain. The fungus then continues to grow rapidly downward where it may

later loosen and debark the entire tree, thus leaving only the bare wood exposed. The presence of this disease explains the common sight on old trees in neglected orchards where one-half of the tree is devoid of bark while the other half has its normal covering. I have observed trees 40 to 50 years old that have such bare spaces two feet wide that extended from below the surface of the soil to a dead limb 10 feet above the ground. Trees that have this disease extending below the ground have their root systems attacked, and should a windstorm arise there is a great possibility of such trees being blown over. The stroma or pustules from which the spores are exuded are not formed on the roots below the surface of the ground but on the exposed roots the pustules have been observed in several cases. On careful examination of the bare spots in the trunks of the trees one can readily find the stroma of the blister canker still clinging to the dead wood. I have made a microscopic examination of such brittle stromatic tissue that was at least ten years old and found that within the perithecia there were many spores. These, when placed in different liquid media did not germinate at all. Some of the spores burst their walls when placed in a 4 percent sugar solution, but such spores, did not send forth a hyphal thread. This would tend to show that the very old spores in the stroma are not capable of germination but that the greatest amount of infection is due to the presence of conidia and the younger ascospores.

Fig. 6. Apple branch with advanced case of Blister Canker. This shows the nailhead-like protrusions or stroma which contain the spores of the canker fungus, *Nummularia discreta* Tul. From Perry county, O., July, 1911.

The blister canker is not without some features that make it peculiar as a disease. This fungus may produce a canker in the center of a large branch and naturally it will send its mycelium into the heart-wood, where it dissolves the tissues, and in conjunction with the oxidation of the air produces the dark-brown color which is characteristic of the brittle diseased wood. Should there be a wound below the cankered surface which is of some size and which has dried the heart-wood, the fungus will grow toward this wound and produce a cankered surface similar to the one above. I have had occasion to observe such cankers upon a limb six inches in diameter where the cankered area, with its stroma sending forth spores, was at least ten feet in length. Another peculiarity that the fungus gives to its host is that it readjusts the sap flow in such a manner that often when a canker is removed there exudes from the discolored, infected heart-wood, a sap which emits a slight odor and which has a great tendency to attract flies. Fig. 2 shows a one year old canker which was removed, and Fig. 3 was taken immediately after its removal. The latter shows the discolored area. This water is conducted toward the center of the branch by the medullary rays and is then conducted upward by the old tracheal tubes.

Both these tissues may be attacked by the fungus and it is because of this pathological condition that we have this peculiarity of the great sap ascent in the heart of the diseased limb. The two factors of the rapid fungus growth in the heart wood and also of the sap flow in the same tissue make it difficult and almost impossible to control this canker, once it has a foothold upon the tree.

EXPERIMENTAL STUDIES OF THE FUNGUS

During the year 1911 experiments were conducted in the laboratory as well as the orchard in trying to find methods to combat the canker successfully. To understand more clearly some of the traits of this disease, I took portions of branches of Grimes Golden that were as thick as one's thumb, weighed and inoculated them and kept them under different conditions. Some were sterilized by steaming for two hours in an autoclave at 15 lbs. pressure; some were sterilized in mercuric chloride for one-half hour; some were left unsterilized in the open air with or without being dipped in water; some were sterilized in bichloride and kept in test tubes with or without being dipped in water; while others were dried until they had lost about 20 percent of water before they were inoculated. These experiments were conducted in December when the sap flow is generally scarce, but drying portions of the branches in an oven at 100° C. until the weight was constant showed that they contained

from 42 to 43 percent of water. Of all the inoculations the most rapid growth of the fungus was observed in the branch in which about 20 percent of the water was driven off. On the third day after inoculation, in spite of the loss of water by drying, globules of sap were seen exuding from the distal end as well as from the wound left by the removal of the side branches. Four days later the proximal end of the branch, which was about eight inches from the point of inoculation, was examined and the presence of the mycelium was found in the woody tissues of the heart wood, but not in the conductive tissue. Other portions of branches left under conditions which permitted evaporation only showed signs of growth of the fungus when about 10 percent of the watery content had passed off in evaporation. Portions of branches that were sterilized in steam and had excess of water present, so as to increase their watery content, did not show the presence of the fungus in the woody tissue. These experiments would indicate that to enable the fungus to grow there must be a certain amount of air or oxygen present. This oxygen may be introduced into the tissues by the replacement of the evaporated water by air or by the conduction of the sap which, as we know, carries considerable oxygen and other gases. Both of these factors may be the means of supplying the fungus with the necessary oxygen; similar conditions are also observed in the orchard. Whenever a branch or limb is removed and no protective covering applied, the tissues dry and are very susceptible to the attack of not only the blister canker but to other wound fungi as well.

Fig. 7. One side of apple trunk killed by Blister Canker. Note that branches were killed by the disease which, independent of their removal, has extended in a narrow strip almost to the ground. Perry county, July, 1911.

Experiments were conducted in the orchard to see whether or not some means could be found to treat cankers so as to prevent the ravage of this fungus. The most of the experiments were conducted in the orchard of Mr. D. F. Jones, Jackson, Ohio, who has aided me greatly in this work. In some cases the cankered limb was removed and left unprotected, or the wound was covered with either white lead paint, asphaltum or

paraffin. In other cases the diseased bark was cut away and the wound treated with asphaltum. In removing the limbs in April and May it was found that the bark tended to separate readily from the wood tissues, due to the formation of the new tissues. Usually the wounds became larger than was desired. These diseased wounds were examined from time to time and it was soon found that conditions arose that made it difficult to treat the disease. A short time after the substances were applied it was observed that the covering became blistered and filled with water or sap which exuded from the tissues below. Some of these blisters were two inches in diameter and were often over half an inch high. These were observed to burst and thus become an ideal place for fungi and bacteria. These same conditions were observed where the cankered limb was cut off or the diseased bark was removed and the wound treated. Some of the wounds that had the bark removed and were covered with a dressing showed that the fungus continued to grow in spite of the covering. This may be explained in that all the diseased bark may not have been removed, or that the fungus infected the healthy bark by growing from the diseased heart wood. Wounds that were made in April and which served as control or checks, i. e., those that were not treated at all, in October showed a sap flow coming from the center of the wound, and upon this fungi and bacteria grew and formed a slime flux.

PRACTICES OF ORCHARD OWNERS

In November, 1911, an information blank was sent out from the Department of Botany in connection with Press Bulletin 327, and the summary of these reports may be interesting. About 500 blanks were sent out and up to January 9th, 1912, 96 reports were received from 49 counties. The greatest number of reports came from Washington county, to which about 45 blanks were sent, 11 of which were returned. Franklin, Licking, Lawrence, and Washington counties were the only counties that sent more than four reports. The answers to the questions on the information blank show that in the 1311 acres of bearing apple trees reported, 611 trees had been killed in the last two years from some cause or other. In regard to inquiry as to whether or not dressings were used for wounds, 32 answered in the positive; 46 stated that no dressing was used; and 16 made no report. Of the number using dressings 29 used white lead paint, who report the success as follows: 16 had good results; 3 had fair results; 1 reported poor results; and 9 made no report. One party used grafting wax for wounds with good results, and another used carbolinium with doubtful results. In regard to the question as to whether or not there was a possibility of loss due to canker,

18 made a positive answer; 52 a negative answer; and 24 left a blank. Considering the blank as a negative answer one would have a total of 76 negative answers. The question was also asked whether or not special advice was desired in regard to the canker: 25 made a positive answer; 35 a negative answer; and 34 left a blank. Considering the blank as a negative answer the results show that 25 desired assistance in regard to the treatment and prevention of this disease, while 69 did not need assistance or were indifferent.

PREVENTION OF BLISTER CANKER

The recommendations for the prevention of this disease have been known for many years. In cutting a branch from a tree it is desirable to make thecut smooth and close to the member from which it is to be severed and to cover wounds that are larger than an inch in diameter It would be still better to cover all wounds with some dressing, but generally this is not practical. During the past season we have used paraffin, thick white lead paint, and asphaltum and it will require further experiments and more time is necessary before definite conclusions can be drawn. The substance known as asphaltum is an oil refining product that has a variable melting point depending upon its source. However, this varies from 225 to 285 degrees F. While this temperature is its melting point, it cannot be applied at such temperature because it becomes rigid as soon as cooled to a very slight degree; hence, it is necessary to apply this substance at a temperature somewhere near its boiling point, which is in the vicinity of 450 to 500 degrees F. This is applied with a daub or brush and as soon as it cools it forms a semi-rigid covering. This covering is soft similar to heavy tar, in summer, while in winter it has a tendency to become brittle and may crack. This crack may be closed again later in the year. The paraffin used was the same as that ordinarily applied for sealing purposes and has a melting point of 113 to 125 degrees F. To apply this it is necessary to have a blow-torch to heat the paraffin to a liquid condition. This, however, is objectionable because of the possibility of injury caused to the growing tissues. It is generally agreed that some substance is necessary to protect the wounds by preventing drying out of the tissues and a subsequent infection. As yet we are unable to state positively which of the substances mentioned is the best.

SANITATION WORK IN THE ORCHARD

Other protective measures consist in spraying and removing the dead brush from the orchard. In spraying trees while in foliage the great mistake made by many growers is in not spraying the trunks and large branches of their trees. They have been spraying for scab, i. e., spraying the apples and foliage only and have forgotten that there are other diseases that live in the bark and wood of the tree which require attention. Some orchardmen neglect to gather all the pruned brush and some men pile the same outside the orchard, usually in a ditch, and allow the wood to decay as best it can. It is true that such brush prevents erosion, but it is also true that such brush is a real hot-bed for fungus diseases. It is a common sight to see side by side a well kept commercial orchard and a neglected, unkept orchard with its many dead trees and branches. It is necessary to advise one's neighbors in regard to the blister canker, for no fence is high enough to keep it out. The best policy is to burn the brush and thus prevent trouble that maycause financial loss. Should an entire tree be found to be killed by some cause or other it is always advisable immediately to grub it out rather than to cut it off near the surface of the ground. Should any portion of the dead tree be allowed to remain in the soil it is very subject to the attacks of the root rot fungus (*Armillarria mellea* L.), and from there the disease may spread through the ground to neighboring healthy trees. It is clear that orchard sanitation is necessary, and that it requires but little labor if constant vigilance is kept against the blister canker or any disease that desires to introduce itself.

SUMMARY

1. In the southern and eastern portions of Ohio the condition known as a "neglected apple orchard" is for the greater part caused by the blister canker fungus, *Nummularia discreta*.

2. The fungus, being a wound parasite, is difficult to control when once it has taken a hold of a tree and except in cases of slight attack, the tree ultimately will succumb to this disease.

3. To prevent infection from the blister canker fungus it is necessary to prevent the drying of the tissues, which is done by covering the wound with a suitable dressing.

4. Prevention of infection and orchard sanitation, as by removal and destruction of diseased parts, appears to be the only method of controlling the blister canker in Ohio.

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